APPENDIX 13-1

GATE EVALUATION TECHNICAL MEMORANDUM

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BLACK & VEATCH

TECHNICAL MEMORANDUM

South Florida Water Management District
EAA Reservoir A-1
Work Order No. 10

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Gate Evaluation Technical Memorandum

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From: Kevin Lee, Denton Voss, Jim Touslee

1. INTRODUCTION

In October 2003, South Florida Water Management District (District) decided to pursue a "Dual Track" for the Everglades Agricultural Area (EAA) Reservoir project. While the multi-agency Project Delivery Team, lead by the Corps of Engineers, continues to develop the Project Implementation Report, the District is proceeding with the design of a reservoir (designated EAA Reservoir A-1 Project) located on land acquired through the Talisman exchange in the Everglades Agricultural Area.

The purpose of the Project as defined in the CERP is to capture EAA Basin runoff and releases from Lake Okeechobee. The facilities will be designed to improve the timing of environmental water supply deliveries to STA 3/4 (Storm Water Treatment Area 3/4) and the WCA's (Wetland Conservation Areas), reduce Lake Okeechobee regulatory releases to the estuaries, meet agricultural irrigation demands, and increase flood protection within the EAA.

2. OBJECTIVES

The objectives of this Technical Memorandum are to:

- Discuss various applicable gate types (such as vertical roller lift gates, radial (or taintor) gates, and crest (or bottom-hinged flap) gates) with regard to:
    - cost
    - maintenance
    - flexibility
    - ease of operation
    - remote sensing
    - power requirements
    - automated control
    - debris control
- Summarize conceptual costs for the various gate types
- Discuss various control structure locations and arrangements. Required gate structure include the following:

- between STA 3/4 Supply canal and the EAA Reservoir A-1, east of gate structure G-383
- between STA 3/4 Supply canal and the EAA Reservoir A-1, west of gate structure G-383
- near the G-370 Pump Station to allow release from the EAA Reservoir A-1 to the suction canal that feeds G-370
- adjacent to the new Northeast Pump Station to allow release from the EAA Reservoir A-1 to the North New River canal (for agricultural releases)

3. GATE OPTIONS

3.1 General

There are several types of water control gates that could be utilized for the service required for the EAA Everglades EAA Reservoir A-1 project. The typical use of a water control gate on the project will be for release of water from the reservoir or conveyance from the STA 3/4 supply canal to the reservoir. Vertical roller lift gates are typically used as a standard gate type for District projects. This is in large part due to the District's familiarity with operations and maintenance with them. A description of the advantages and disadvantages of vertical roller lifts gates as well as descriptions of 2 alternative gate types are included herein.

3.2 Vertical Roller Lift Gate

Vertical roller lift gates are typically used where opening sizes are too large to efficiently use slide gates, or applications where gravity closure is a requirement. A vertical roller lift gate is usually rectangular in shape consisting of a structural framework, a skin plate on at least the upstream side, and multiple rollers located on the sides of the gate. These rollers fit in a slot constructed in the sides of the piers. Figure 1 shows a vertical roller lift gate being installed. Figure 2 shows a schematic of a slot with a roller installed.

One of the benefits of the vertical roller lift gates is its small footprint area. As it lifts straight up from its closed position, the structural requirements for the gate in an open position are directly above the gate. This results in a smaller footprint area, and more flexibility regarding where the gate structure can be located, especially relative to pump stations. Figure 3 shows an example of the overhead structure.

Another benefit of a vertical roller lift gate is its flexibility. Due to its shape, and its ability to seat in a downstream or upstream condition, it can permit bi-directional flow. This is especially important in the case of the control structure located between the STA 3/4 supply canal and the A-1 Reservoir which most likely will allow flow from the supply canal into Reservoir A-1 and will allow flow from Reservoir A-1 into the STA 3/4 supply canal at different operating conditions. Additionally, since a vertical roller lift gate will seat along its bottom edge, it can easily be incorporated into a spillway design, such as an ogee spillway or a trapezoidal spillway such as might be used for a situation of bi-directional flow.

Maintenance is a consideration for the vertical roller lift gate. The mechanical portions of the gate, specifically the rollers, are typically in a wet state, depending on whether a seal is incorporated or not. If a large amount of debris is present, it is possible that debris could penetrate through a seal and jam a roller. In this case, it is very difficult to service the gate. Additionally, balance of the gate relative to the rollers is very important. Uneven contact of a roller can overload adjoining rollers. Therefore, proper installation of a vertical roller lift gate is critical to its performance.

There is no debris control inherent to a vertical roller lift gate. Typically debris remains upstream of the gate if the gate is less than 75% open. Therefore, the capture or exclusion of debris from the gate would require an additional feature. For the control structures associated with Reservoir A-1, debris is not expected to be a major design consideration. Therefore, no additional features are planned at this time. The only situation where debris will be collected is at pump station inlets, and these features will need to be incorporated into the pump station design or modifications.

Finally, remote sensing is quite simple with vertical roller lift gates. Stem height indicators could be utilized. This data could then be incorporated with an electronic decision making tool, such as a SCADA system, and the gate can be automatically opened or closed based on current operating conditions. Since automated control is to be incorporated, each gate would need its own actuator.

3.3 Gate Alternatives

3.3.1 Radial (Tainter) Gate

A conventional radial gate consists of a curved skinplate, structural framework, and radial arms. Radial gates are typically used on large openings where vertical lift gates are less practical. They are usually operated by cable or drum hoists to allow for full travel with minimal overhead super structure. Rubber seals are attached to the sides and bottom of the gate and seal on stainless steel plates embedded in the adjacent concrete. Figure 4 shows a radial gate in service. Figure 5 shows a cross sectional schematic of a radial gate.

Construction of the gate itself offers an overall economy compared to vertical roller lift gates. Since radial gates do not rely on gravity, and therefore the weight of the gate, to seal the gate, radial gates typically weigh much less and have simpler structural frames. Additionally, installation of a radial gate is simpler due to the ease of installation and alignment of the trunnions, embedded side plates, and sill members compared to installation of the slot and balancing of rollers associated with vertical roller lift gates. These factors contribute to lower costs associated with radial gates. For example, a 12-ft by 12-ft radial gate should cost on the order of $150,000 where a 12-ft by 12-ft vertical roller lift gate should cost on the order of $225,000.

Structural requirements for radial gates are somewhat different from vertical roller lift gates. Where the structure associated with a vertical gate is mostly an overhead structure, the radial gate also requires a larger downstream flume to house the gate's components for opening and closing in addition to the overhead requirements for actuation. Therefore, structural costs would be somewhat more for radial gates, and would require more footprint area. This serves to reduce some of the saving associated with cheaper fabrication costs.

Due to the curved upstream surface and radial arms, radial gates lack the flexibility required to incorporate bi-directional flow. Therefore, at control structures where this is required, additional gate bays would have to be added for flow up- and down-stream or vertical roller lift gates would have to be incorporated at these locations. As with the vertical roller lift gates, radial gates are easily incorporated into spillway designs such as ogee or trapezoidal spillways due to their bottom edge seal.

Maintenance requirements for radial gates are minimal due to their lack of mechanical components. Additionally, if service is required on a structural component or the trunnion (such as regular greasing of the trunnion), these features are located in dry conditions when the gate is closed. This aids in ease of maintenance. Additionally, debris control for radial gates is similar to that of vertical roller lift gates as described above.

Remote sensing and automated control is more of a challenge compared to vertical roller lift gates. Since the actuation mechanism is typically a cable drum-type component as illustrated in Figure 6 below, remote sensing would have to measure revolutions of the drum or the actuator. It is less common that radial gates incorporate remote sensing due to this fact, though not necessarily impossible. Further action would be required to incorporate remote sensing and automated control with radial gates.

3.3.2 Crest Gate

Crest gates are bottom hinged gates used for precise water level control. They are typically hydraulically operated to allow for opening during power outages in flood events. The hydraulic cylinders may be located either below the gate or at each end of the gate atop the adjacent piers depending on site conditions. Rugged rubber seals are provided at each end and along the bottom of the gates to efficiently minimize leakage.

The most obvious benefit of crest gates also results in a potential disadvantage. Crest gates can be used to provide various water levels for the reservoir. However, they do not seal along their top surface, and therefore, cannot be used in a submerged service application. Therefore, in order to include a crest gate in a control structure design, the gate would need to be tall enough to impound storm events, and be capable of withstanding wave action. This would require a much larger gate than would be necessary to release water if using a vertical roller lift gate or a radial gate, and thereby would not be a cost effective solution.

However, if uncontrolled spillways are required, as currently stipulated under the District's Design Control Memorandum 3 (DCM-3), and this spillway is established at the normal water level of 12-ft, crest gates might become more cost effective. If this decision is made at a later time, further consideration should be given to crest gates as there are other advantages that they offer besides water level control.

4. CONTROL STRUCTURES

4.1 General

In addition to gate type, the size and configuration of control structures requires further discussion. The location and size of the gate structures is affected by expected passing flowrates, the operations plan for Reservoir A-1, the current operations of STA 3/4, and past records of agricultural demands. Figure 9 shows the general location and flowrates for each control structure. Gate analysis summarized herein is for the submerged gate condition (i.e. orifice flow). Gates whose invert elevation is near the reservoir bottom elevation of 8.6 (NAVD) would act more as weirs at low reservoir elevations.

Where gate widths are given below, they refer to a total width of open gate area, and not the width of a single gate. Individual gate size is limited by shipping requirements where at least one side (height or width) must be 10-ft or less in length. Gate size is also limited by weight and its corresponding structural integrity and lifting capacity. This is especially true for all stainless steel components. Therefore, bays of multiple gates will be used to achieve the required gate width as described in the following sections.

As shown in the District Standard Guidelines on Sheet 1 of G-S1, the District's gate designs typically incorporate a weir at the bottom of the gate. One benefit in incorporating a weir is for flow calculations. For gate locations where one directional flow will occur, an ogee-type weir as specified in the Standard Guidelines could be implemented. However, for gate locations where two directions flow will occur, a trapezoidal-type weir should be implemented instead.

4.2 Discharge to North New River Canal (NNRC)

The design flowrate for the control structure located adjacent to the new Northeast Pump Station is controlled by irrigation demands. Historical data for irrigation demands were integrated within the water balance model to create the background shown in Figure 10. Head/capacity curves for a bank of gates of varying width were then superimposed over the background. Head/capacity curves were prepared for 10, 25, 50, 75, 100, and 200-ft widths. Based on this, it appears that a bank of gates approximately 50-ft wide would meet most of the historical demands and therefore should satisfactorily meet most future demands.

4.3 Discharge to G-370 Pump Station

When reservoir levels fall to a level for which gravity flow from the reservoir to the STA supply canal is no longer viable, water will need to be released downstream of G-370 to be pumped into the supply canal. Therefore, the design flowrate for the control structure located adjacent to the existing G-370 Pump Station should match demand in STA 3/4. In order to maintain the average demand of 6-cm/day of additional water to the STA, a flowrate of 1645 cfs is required to pass to STA 3/4. As graphically represented in Figures 11 and 12, a 50-ft bank of gates should be sufficient to pass the 1645 cfs as required.

[Since the draft of this technical memorandum was submitted, it was decided that flow could be passed through the Northeast PS control structure, to the North New River canal, and into the G-370 suction canal with acceptable amounts of headloss. Thus, a discharge structure at G-370 to the suction canal would not be a necessary expenditure.]

4.4 Discharge between Reservoir A-1 and STA 3/4

The direction of gravity flow between Reservoir A-1 and STA 3/4 will fluctuate due to the differential levels between the two. When the reservoir water level is lower than the STA supply canal levels, flow can be pumped from G-370, G-372, or both pump stations into the supply canal and then discharged by gravity into the reservoir. This is shown in Figure 13 below. When Reservoir A-1 levels are greater than those in the STA supply canal, gravity flow from the reservoir to the supply canal can occur. This is shown in Figure 14 below. Gates need to be sized for the more conservative situation. This occurs when both pump stations are pumping into Reservoir A-1. Therefore, 75-ft of gate width is required for this control structure.

Due to the gate control structure G-383 located in the STA 3/4 supply canal to the west of G-370, it is important to ensure that flow from both pump stations can enter the reservoir when G-

383 is closed. Also, it is important to ensure that flow can be distributed to the various areas of the STA when G-383 is closed. Therefore, the 75-ft of gate width should be divided into two control structures, one located on each side of G-383. The division required by flow demands would be met with 45-ft of gate structure to the west of G-383 and 30-ft of gate structure to the east. This is illustrated in Figure 9 as well.

5. REFERENCES

Lewin, Jack. Hydraulic gates and valves in free surface flow and submerged outlets. London: Thomas Telford Publications, 1995.

"Engineering and Design – Hydraulic Design of Spillways", United States Army Corp of Engineers, Publication Number: EM 1110-2-1603, Chapter 6 – Crest Gates, January 16, 1990.

SFWMD Standard Details and Standard Guidelines, August 2004.

http://www.steel-fab-inc.com/gates.html

http://www.hydrogate.com

http://www.rodneyhunt.com/gates.htm

FIGURES

Figure 1 Vertical Roller Lift Gate

Figure 2 Roller/Slot Interface

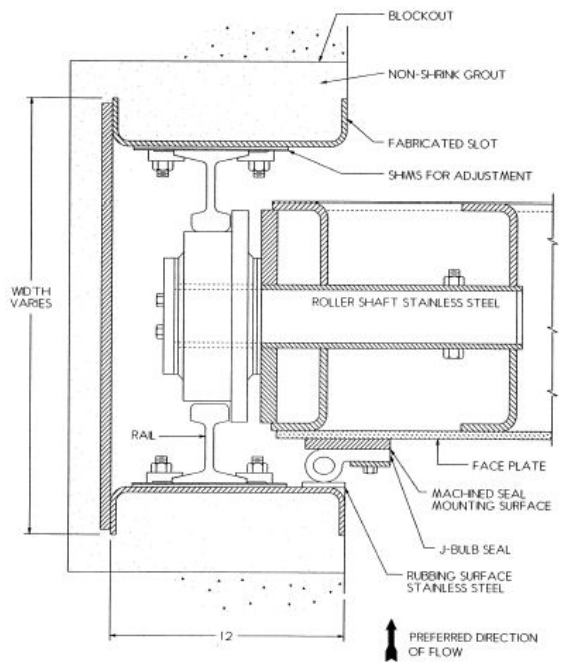


Figure 3 Vertical Roller Lift Gate Overhead Structure

Figure 4 Radial (Tainter) Gate

Figure 5 Radial Gate Diagram

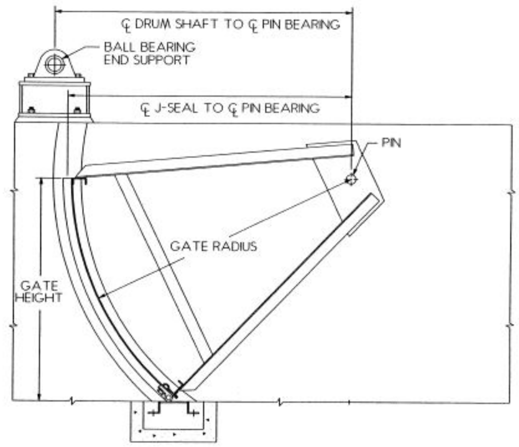


Figure 6 Radial Gate Cable Drum Manual Actuator

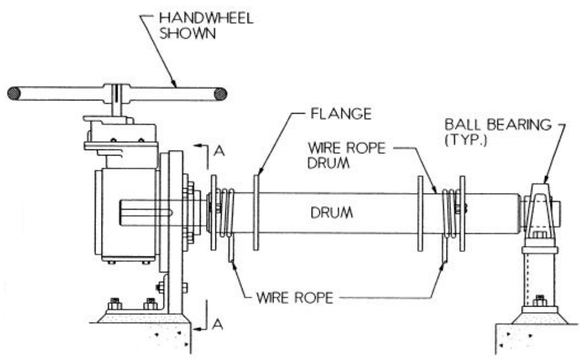


Figure 7 Crest Gate

Figure 8 Crest Gate Diagram

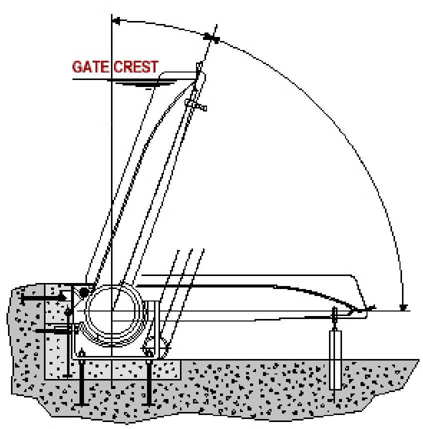


Figure 9 Control Structure Overall Plan

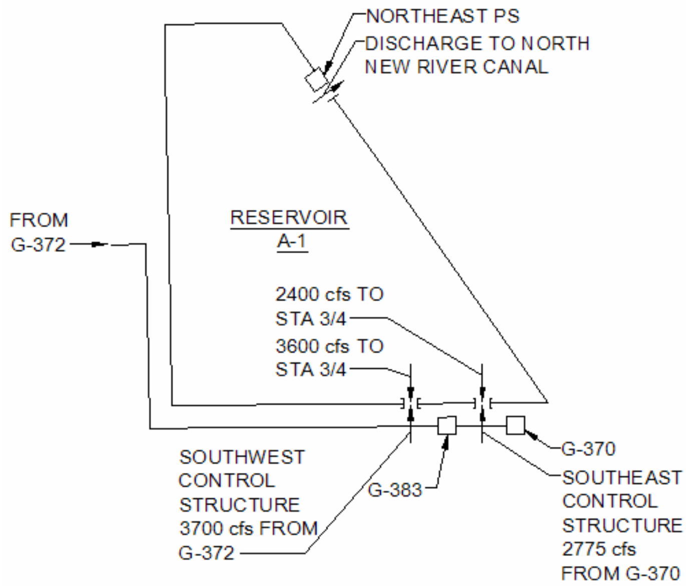


Figure 10 Northeast PS Gate Curve

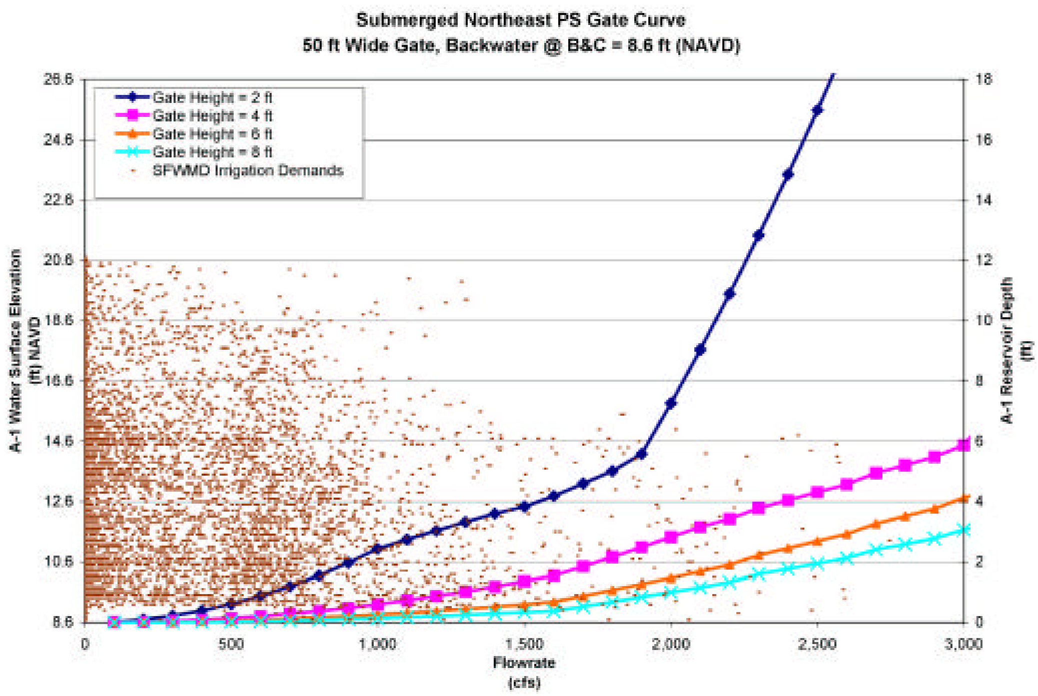


Figure 11 G-370 Suction Canal at EL 8.6

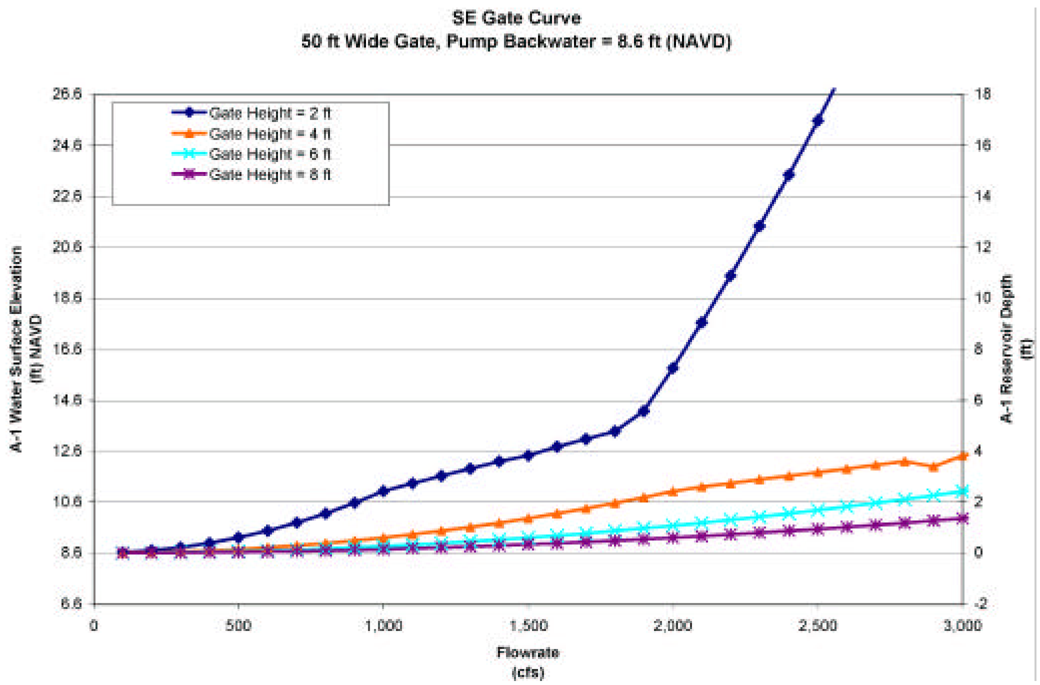


Figure 12 G-370 Suction Canal at EL 6.6

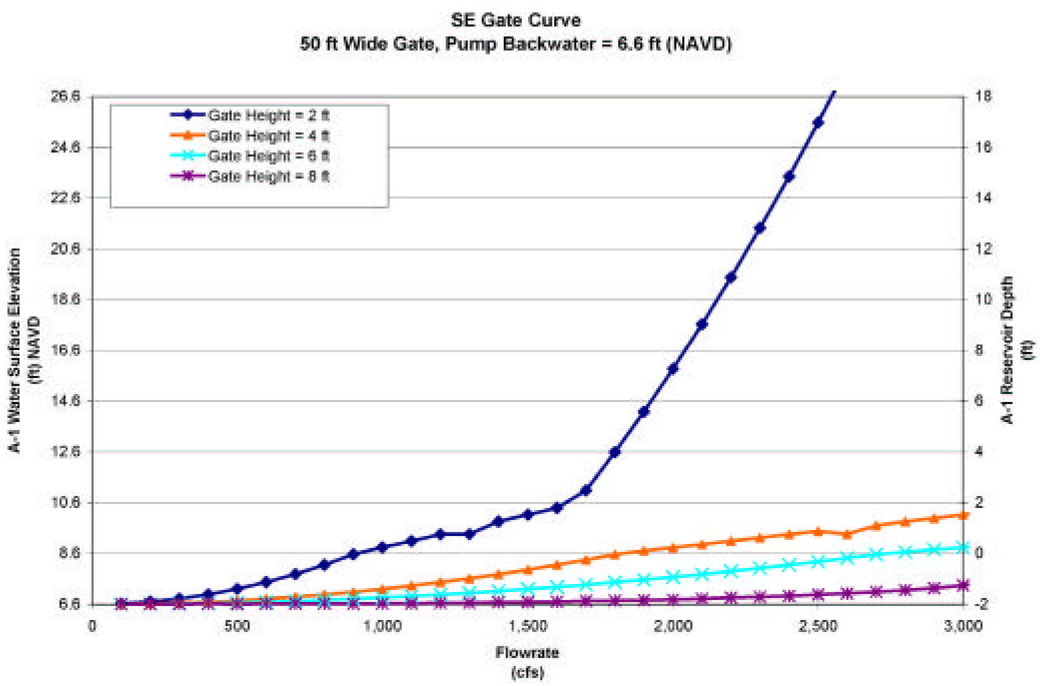
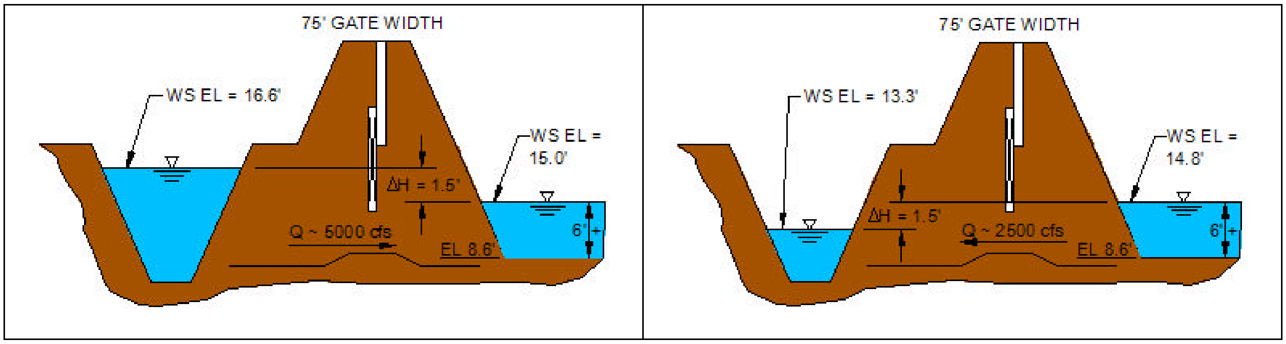


Figure 13 Flow into Reservoir A-1	Figure 14 Flow into STA 3/4 Supply Canal


75' GATE WIDTH
WS EL = 16.6'
WS EL = 15.0'
ΔH = 1.5'
Q ~ 5000 cfs
EL 8.6'
6'+
75' GATE WIDTH
WS EL = 13.3'
WS EL = 14.8'
ΔH = 1.5'
Q ~ 2500 cfs
EL 8.6'
6'+